B. AMSC Can Provide CDMA MSS in the 1610-1626.5 MHz/2483.5-2500 MHz Bands Consistent With Existing Regulations, and Would Pose Less Interference Problems Than the Non-Geostationary Systems

AMSC can provide MSS using CDMA in a manner consistent with the existing rules and regulations for the 1610-1626.5/2483.5-2500 MHz bands. Indeed, as discussed above, since AMSC's system operation will be confined to North America, AMSC will be better able than the proposed non-geostationary systems to coordinate the use of these bands with foreign administrations.

With respect to the 2483.5-2500 MHz downlink band, there is yet another reason why AMSC would pose far less interference problems in this band than the proposed non-geostationary systems. The international PFD thresholds governing MSS operation in this band were originally developed as coordination triggers specifically for geostationary MSS systems. They were not designed to deal with MSS systems utilizing constellations of satellites in non-geostationary orbit, which are constantly moving near or directly through the mainbeams of terrestrial fixed receiving antennas. As a result, a non-geostationary MSS system operating at the international threshold would cause far more interference than a geostationary system operating at the same level.

The Commission has specifically solicited comment on how to treat the international PFD thresholds in the 2483.5-2500 MHz band with respect to the proposed MSS systems. The attached Technical Appendix explains in detail that for the reasons set forth above, the ITU PFD thresholds must be treated as absolute limits with respect to non-geostationary systems but should serve only as coordination triggers with respect to geostationary systems. This analysis demonstrates that under a CDMA sharing approach, AMSC is in fact better able to operate in the new proposed MSS downlink band than the non-geostationary systems.

V. Handheld Terminals Associated With the Proposed Non-Geostationary Systems May Pose an RF Radiation Hazard

As explained in the attached Technical Appendix, AMSC believes that the handheld units to be employed in connection with the proposed non-geostationary MSS systems present a potential RF radiation hazard to users. AMSC's first-generation vehicular-mounted mobile earth terminals do not pose such a hazard, and AMSC's second-generation system is designed to involve handheld units that will operate at safe power levels.[18]

Conclusion

AMSC urgently needs additional spectrum for the full development of its MSS system, and it therefore supports the domestic allocation of the 1610-1626.5 MHz and 2483.5-2500 MHz bands to MSS. While AMSC questions the ability of these bands to support the multiple non-geostationary MSS systems

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18/ *See* Petition of AMSC, RM-7806 (June 3, 1991), Exhibit B.

that the Commission appears to envision, AMSC is willing to cooperate with the non-geostationary system applicants toward formulating a solution by which all the pending MSS applicants can share the bands. AMSC urges the Commission to adopt its proposed allocation and ensure that at least a portion of these bands is available for the U.S. MSS system.

Respectfully submitted,

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TECHNICAL APPENDIX

TECHNICAL APPENDIX

INTRODUCTION

This Appendix addresses technical issues regarding the Commission's Notice of Rule Making and Tentative Decision in ET Docket No. 92-28, which proposes to allocate the 1610-1626.5 MHz and 2483.5-2500 MHz bands for use by geostationary and non-geostationary Mobile Satellite Service ("MSS") systems.

Section I of this Appendix discusses the potential of MSS systems operating in the 1610-1626.5 MHz band to interfere with the Glonass aeronautical radionavigation system, which operates between 1602 MHz and 1616 MHz. Section I contains an analysis demonstrating that even at relatively low effective isotropic radiated power ("EIRP") levels, mobile earth stations will cause severe harmful interference to Glonass aircraft receivers operating at distances of several hundred kilometers unless MSS operations are confined to frequencies well above 1616 MHz. It is also shown that similar frequency assignment constraints would be needed to protect Glonass receivers from MSS downlinks.

Section II discusses the interference potential of bidirectional operation in a portion of the 1613.8-1626.5 MHz band. The analysis is Section II demonstrates that secondary MSS downlink operations in this band would cause severe interference to other MSS systems operating uplinks on a primary basis.

Section III addresses the ability of multiple non-geostationary MSS systems to operate in the 1610-1626.5 MHz and 2483.5-2500 MHz bands. The analysis in Section III shows that under present international regulations governing these bands, each of the four non-geostationary MSS systems proposing to share the bands through use of code division multiple access ("CDMA") techniques would have only nominal capacity.

Section IV discusses the Commission's proposed power flux density ("PFD") thresholds for the 2483.5-2500 MHz band. As shown in this section, the international PFD thresholds should be applied as coordination "triggers" for geostationary MSS systems, but as absolute limits for non-geostationary MSS systems.

Section V of this Appendix addresses issues concerning radio frequency ("RF") radiation hazards. While AMSC's proposed mobile earth stations present no potential RF hazard to users, AMSC's analysis suggests that such a problem could exist with respect to the hand-held terminals to be used with some of the proposed non-geostationary MSS systems.

Finally, Section VI of this Appendix addresses the ability of geostationary MSS systems to share the proposed new MSS bands with non-geostationary systems, as well as, the impact of multiple access techniques on sharing. It dispels the notions that: (1) geostationary MSS systems cannot share with MSS systems, (2) FDMA, FDMA/TDMA, and FDMA/CDMA cannot be intermingled, and (3) any particular multiple access technique is superior in the multiple access environment.

I. MSS OPERATIONS BELOW 1616.5 MHz WOULD CAUSE SEVERE HARMFUL INTERFERENCE TO AERONAUTICAL RADIONAVIGATION

In positing MSS allocations for the 1610-1626.5 MHz band, the Commission expressed concerns about the impact of coordination with the Glonass system and the attendent frequency sharing solutions.[1] Indeed, this matter is a critical factor in deciding the nature of MSS allocations within the 1610-1626.5 MHz band because MSS is incompatible with Glonass. Specifically, MSS uplink or downlink transmissions at frequencies close to those used by downlinks in the Glonass satellite system will cause severe harmful interference to Glonass receivers. Thus, the focus of international coordination of planned MSS networks with Glonass operators and users will be on the frequency separation need to preclude unacceptable levels of interference. Because Glonass signals for civil aviation extend from below 1610 MHz to at least 1616.011 MHz, and because several hundred kilohertz of frequency separation is needed between Glonass and MSS signals, domestic MSS allocations should not extend below 1616.5 MHz and additional frequency separation constraints should be established during domestic and international coordinations. Of course, even greater frequency separation constraints will be needed for non-geostationary MSS operations over oceans and other areas outside the U.S. where protection of Glonass supplemental precision navigation signals is required; these signals extend upwards to 1621.1 MHz. Glonass-M, IFRB weekly circular 2022, AR11/A/807.

Glonass provides Aeronautical Radionavigation service as part of the FAA Future Air Navigation System and the Global Navigation Satellite System ("GNSS") planned by the International Civil Aviation Organization, which entitles Glonass aircraft receivers to the highest recognized degree of protection from

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[1] NPRM, at ¶ 30. Over a year and a half ago, the Commission expressed concerns about the interference problems between MSS and the Glonass aeronautical radionavigation system in the 1610-1626.5 MHz band and requested studies on these problems. See Supplemental Notice of Inquiry, Gen Docket No. 89-554 (WARC-92), March 20, 1991, ¶21. The subsequent comments by proponents of MSS failed to show that interference could be held to acceptable levels under any circumstances, and AMSC showed that co-channel operation between Glonass and MSS would not be possible. Moreover, in its Application to construct and operate an MSS (Earth-to-space) system in the 1610-1626.5 MHz band, AMSC proposed to confine its uplinks to frequencies above 1616.5 MHz in order to ensure that a substantial guardband would be available for protection of Glonass. Petition of AMSC, June 3, 1991.

interference.[2] Aviation and other users of Glonass may be located anywhere throughout the world, and Glonass receivers may be incorporated in spacecraft in low Earth orbit (including over the U.S. at times) in support of certain missions (e.g., Earth observation missions requiring precise correlation of spacecraft location and sensor data). Thus, Glonass receivers would be continuously illuminated by MSS downlinks and there is no may to assure compliance with distance separation constraints between Glonass receivers and mobile earth station uplinks.

The guaranteed signal level at the antenna terminals of a Glonass receiver is -161 dBW and the permissible level of interfering signal power density is -177 dBW/50 Hz.[3] A spread spectrum MSS uplink from a hand-held mobile earth station may generate an EIRP density on the order of -34 dBW/50 Hz (e.g., assuming that it is radiating at an EIRP between 3 dBW and 4 dBW spread to meet an EIRP density threshold of -15 dBW/4kHz, which serves as a special coordination trigger in RR 731X). In order to attenuate the interfering EIRP to the permissible level, a separation distance of 237 kilometers is needed between the mobile earth station and the Glonass receiver, assuming that no foliage or other shielding effects are present. Thus, if concurrent interference from MSS downlinks is disregarded, a Glonass receiver on an aircraft flying at 14,500 feet could not tolerate the interference from just one co-channel hand-held terminal operating in the aircraft's field of view (an area that covers 68,153.5 sq. mi.). An even larger "blackout area" for the spread spectrum MSS uplinks would be associated with aircraft at lower altitudes, as would be the case for the critical landing approach operations that may be facilitated by Glonass. When an

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[2] See RR Nos. 56, 163, and 953. For further information on Glonass, <u>see</u> RTCA Paper No. 518-91/SC159-317, "Global Satellite Navigation System GLONASS," Interface Control Document (Second Wording). This document is the principal source for the Glonass parameters specified in this appendix. Several Glonass satellites are currently in operation and the constellation eventually will be comprised of 24 satellites for reliable, full-time global coverage. The satellites transmit carriers in the 1602.5625 - 1615.5 $\pm$ 0.511 MHz band at nominal carrier frequencies defined by the expression $f_k = f_o + Kf_d$, where K = 0,1,2,..24, f_o = 1602 MHz and f_d = 562.5 kHz, and the transmission rate of the pseudo-random ranging code is 511 kbps onto which navigation information at a rate of 50 bps is modulo 2 added.

[3] At the WARC-92, the Russian Federation indicated that the permissible interference level is -177 dBW/50 Hz based on a desired signal level of -161 dBW/50 Hz and a protection ration of 16 dB. WARC-92 Doc. 184.

aircraft enters such a blackout area, the Glonass-based navigation capability is lost and only lower-precision navigational aids will be available to the pilot. As a consequence, closely spaced en-route aircraft may collide or aircraft may miss runways upon landing.

Table 1 describes the MSS uplink interference problem; it lists the required separation distances between a Glonass receiver and one co-channel ground-based mobile earth station transmitter over a representative range of possible uplink EIRP density levels. The table also shows the MSS blackout area in square miles directly under an airborne terminal flying at 25,000 and 40,000 feet. The table can be used to examine the effects of potential shielding by the fuselage. For instance, if 10 dB of aircraft shielding and an uplink EIRP density of -20 dBw/4kHz are assumed, the separation distance and the blackout areas are the same as those listed for the -30 dBW/4kHz EIRP density case listed in the table. Thus, even under conditions of favorably low mobile earth station EIRP density, favorably high aircraft shielding attenuation, and favorably large assumed minimum distance separation, co-channel operation of Glonass and MSS uplinks would result in harmful interference to Glonass.

The presence of MSS downlink interfering signals in addition to MSS uplink interferers merely exacerbates the interference problem. Systems that would operate downlinks under the contemplated MSS (space-to-Earth) allocation in the 1613.8-1626.5 MHz band would need to limit their aggregate co-channel power flux density ("PFD") levels to less than -133 dBW/m^2/4kHz in order to protect Glonass receivers, assuming that an interfering signal power as high as -177 dBW/50 Hz is the applicable aggregate sharing criteria and that no MSS uplinks are also interfering. Consequently, the -120 dBW/m^2/4 kHz PFD levels proposed for individual MSS downlinks would cause harmful interference to Glonass receivers operating on a co-channel basis.[4/]

4/ See Minor Amendment of Motorola Satellite Communications Corp., dated August 8, 1992. The link power budgets presented therein indicate that the average PFD of an individual downlink would be -135.8 dBW/m^2/4 kHz; however, average power is meaningless in cases involving digital receivers such as those used for Glonass. Motorola's downlink EIRP (e.g., 27.7 dBW toward points at 8.2° elevation), bandwidth (31.5 kHz), and spreading loss (e.g., 138.8 dB/m^2 at 8.2° elevation) indicates that the peak PFD (during a 2.4 msec burst) would be -120 dBW/m^2/4 kHz. Such a powerful burst of co-channel interfering signal power would cause complete loss of Glonass receiver synchronization (i.e., outage).

The amount of MSS frequency separation needed with respect to Glonass signals spanning the nominal 1610-1616.011 MHz range depends primarily on the Glonass receiver filter and processor parameters as well as the emission characteristics of the MSS satellites and mobile earth stations. An acutely analogous situation involving the Global Positioning System (GPS) and proposed Aeronautical Mobile base station transmissions was analyzed by the Department of Defense, and it was found that unacceptable interference would occur between mobile transmissions at frequencies that are about 18.6 MHz away from the GPS carrier frequency.[5/] In that study, the narrowband ground-to-air transmissions had an EIRP of 16 dBW, which is about 3 dB and 10 dB higher than AMSC's and Motorola's proposed peak uplink EIRP levels for narrowband signals and about 10.5 dB, 5 dB, 9 dB, and 6.5 dB higher than Constellation's, Ellipsat's, Loral's, and TRW's proposed peak uplink EIRP levels for spread spectrum signals. However, the assumed interfering signal was outside the GPS receiver 3 dB bandwidth and the available frequency dependent rejection was estimated to be 38 dB. In order to allow undistorted reception of the Glonass spread spectrum signals, the 3 dB and 45 dB RF bandwidths of Glonass receivers may be on the order of 20 MHz and 40 MHz, respectively, centered near a frequency of 1608.75 MHz (receivers that also utilize the supplementary precision Glonass-M signal will have substantially wider bandwidths). Consequently, the 3 dB RF bandwidth of the Glonass receiver extends to approximately 1619 MHz, and less frequency dependent rejection will be available from Glonass receivers than was assumed for the GPS receivers. These EIRP and frequency dependent rejection differences may offset one another in the case of AMSC's proposed narrowband uplink emissions above 1616.5 MHz, but greater frequency offsets may be needed with regard to Motorola's proposed uplink and downlink signal bursts and the proposed non-geostationary MSS satellite signals. In any case, for MSS emissions of any type at frequencies below 1616.5 MHz are simply not possible without risking severe harmful interference to

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[5/] See Doc. USSG 8C-254/1 (March 6, 1989) or U.S. IWP 8/14-19, "Feasibility of Frequency Sharing in the 1215-1240 MHz and 1559-1610 MHz Bands Between the Navstar GPS and Terrestrial Radiolocation, Radionavigation, and Aeronautical Public Correspondence Systems." This DoD study was internationally endorsed and encompassed in CCIR Report 766-2. This Report addresses sharing between a single Aeronautical Mobile transmission in the 1593-1594 MHz band and GPS reception at 1575.42 MHz, assuming that the GPS receiver also utilizes the GPS supplemental frequency 1227.6 MHz (i.e., the receiver 3 dB and 45 dB bandwidths are 17 MHz and 50 MHz, respectively). The available frequency dependent rejection with respect to narrowband mobile emissions was determined to be 38 dB, including all filtering and processing effects.

Glonass receivers.

II. DOWNLINKS ASSOCIATED WITH BIDIRECTIONAL MSS POSE SEVERE INTERFERENCE PROBLEMS IN THE 1613.8-1626.5 MHz BAND

The Commission is properly concerned with the feasibility of bidirectional operations as proposed by Motorola and Loral.[6] AMSC's own analysis indicates that MSS downlinks in the 1613.8-1626.5 MHz band would cause severe harmful interference to Aeronautical Radionavigation, Fixed and Radio Astronomy services as well as to any other MSS systems that operated their uplinks in the band.[7] Moreover, because the MSS downlink allocations adopted in the 1613.8-1626.5 MHz band by WARC-92 are secondary, band segmentation and other cooperative approaches to coordination with respect to primary systems cannot be expected to be acceptable, particularly with respect to MSS uplinks as well as the Glonass downlinks addressed in the previous section. Thus, MSS (space-to-Earth) allocations in the 1613.8-1626.5 MHz band should not be adopted domestically.

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[6] NPRM, at ¶ 28-29. Over a year and a half ago, the Commission expressed concerns about the interference problems uniquely associated with MSS bidirectional operations in the 1613.8-1626.5 MHz band, particularly with respect to the Glonass aeronautical radionavigation system, and requested studies on these problems. See Supplemental Notice of Inquiry, Gen Docket No. 89-554 (WARC-92), March 20, 1991, ¶21. The subsequent comments by proponents of bidirectional MSS failed to show either that interference would be at acceptable levels or that the onerous interference from the MSS downlinks operating in an MSS uplink band could be successfully coordinated. Consequently, the U.S. proposed and secured only secondary status for MSS (space-to-Earth) allocations in the 1613.8-1626.5 MHz band.

[7] Prior to WARC-92, AMSC demonstrated that bidrectional MSS in the 1610-1626.5 MHz band would cause harmful interference to systems in the Aeronautical Radionavigation, Fixed and Radio Astronomy services as well as other MSS systems. See, e.g., Supplemental Comments of AMSC, GEN Docket No. 89-554, February 21, 1991, pp. 2-4 and Technical Appendix, and Petition of AMSC, File Nos. 9-DSS-P-91(87) and CSS-91-010, June 3, 1991, pp. 22-23 and Technical Appendix at 4, 6, 12-14, 16-17, 20, 25-28, and 31-42. Out-of-band interference to the Radio Astronomy service may occur from MSS downlinks operating in the 1613.8-1626.5 MHz band; however, the MSS frequency constraints needed to protect Glonass (no MSS operations below at least 1616.5 MHz) may suffice to protect Radio Astronomy.

As illustrated in Table 2, the secondary MSS downlinks would generate levels of interference at least as high as primary MSS uplinks. It is particularly significant that in the case of interference to MSS uplinks, the secondary MSS downlinks generate interfering signal levels that are at least one hundred times (21 dB) more powerful than those of primary MSS uplinks.[8/] In fact, the downlinks of bidirectional MSS systems have far greater interference potential than the associated uplinks. Thus, Motorola's recent proposal to relocate the uplink operations of the other MSS system Applicants to frequencies outside the 1616-1626.5 MHz band is essentially a proposal to displace a primary service by a secondary service.

Even if the Commission were to establish domestic MSS (space-to-Earth) operations in the 1613.8-1626.5 MHz band, there is no way in which MSS downlinks could comply with the sharing criteria that are likely to be needed for protection of MSS uplinks, let alone Glonass downlinks as was discussed in Section I. The annex to this Appendix presents a relevant draft paper for potential U.S. submission to the CCIR Working Party 8D meeting, which will address MSS frequency sharing matters. This paper demonstrates that in order to protect primary MSS uplinks, the EIRP density of MSS downlinks would have to be limited to less than -16.7 dBW/4 kHz in any direction along an Earth tangent. However, EIRP densities on the order of 18.7 dBW/4 kHz must be radiated along Earth tangents in order to provide global coverage.[9/] Thus, the interference from secondary MSS downlinks would be on the order of three thousand five hundred (35.4 dB)

8/ Despite its claim to the contrary, Motorola's recently filed "Minor Amendment" actually proposes higher downlink power levels in the band 1616-1626.5 MHz than were originally proposed, which would compound the interference caused by Motorola's bidirectional operations to systems in the Fixed and Aeronautical Radionavigation services. See Motorola Minor Amendment, August 8, 1992, at 5.

9/ See Motorola Minor Amendment, dated August 8, 1992. EIRP levels as high as 27.7 dBW/31.5 kHz are proposed for the outermost beams which graze the Earth. Motorola has already essentially conceded that it would have to shut off downlink transmissions through satellite antenna beams at times they are pointed near the geostationary orbit in order to protect geostationary satellite uplinks in the MSS. See Doc.USSG 8D-15, "Sharing Between Main Beam Downlink Leo and Uplink GSO Satellites in the 1-3 GHz Allocations", Motorola, 10 July 1991. However, uplinks to LEO MSS satellites also would have to be protected. Because LEO satellites may appear anywhere in the sky relative to a transmitting MSS satellite, Motorola must also concede that it cannot ever use downlink beams that are pointed near the edge of the Earth.

times higher than the permissible level. This interference from secondary MSS downlinks clearly would prevent operation of primary MSS uplinks.

III. THE PROPOSED CDMA SYSTEMS WILL HAVE ONLY NOMINAL CAPACITY

The Commission states that it has little information on the actual volume of communications that can be supported in the proposed MSS systems. NPRM, at ¶18. As discussed in Section VI, CDMA is one among several approaches for achieving multiple entry. However, as in other approaches, each of the systems using CDMA incurs substantial capacity reductions in a multiple entry environment. In fact, even if the frequency sharing problems with other services did not exist, each of the proposed CDMA systems would have capacity no greater than a couple of channels in the multiple entry environment. The capacity problem derives directly from the fact that there is little spectrum available in the 1610-1626.5 MHz and 2483.5-2500 MHz bands to support several systems.

The PFD thresholds adopted by WARC-92 for the 2483.5-2500 MHz band cannot be violated by non-geostationary MSS systems, as shown in Section II. Our analysis of the associated capacity limits assumes that the typical CDMA mobile earth station has 3 dBi antenna gain and noise power density of 25 dBK and that all the systems present are operating at the RR2566 PFD level (-142 dBW/m2/4 kHz for angles of arrival > 25°) on a per-beam basis in order to achieve maximum potential capacity. Assuming that four of the proposed U.S. non-geostationary networks are operating (excluding Motorola because it does not propose to operate CDMA or use the subject band), these systems will produce an interfering signal power density ("Io") level of -194 dBW/Hz at the receiver, resulting in a total noise power density ("$I_o + N_o$") of -193.5 dBW/Hz (excluding self-interference among downlinks in the same network). Table 3 summarizes capacity estimates for each of these CDMA systems assuming that the specific parameters currently proposed for each system are used. The results indicate that the capacity of the proposed CDMA satellite systems would be limited to only a few channels (the Odyssey system would not be able to operate at all as currently designed).[10]

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[10] Of course, it is anticipated that regardless of the multiple access approach(s) that may be recommended by the proposed Negotiated Rulemaking Committee, all applicants for MSS systems in the 1610-1626.5 MHz and 2483.5-2500 MHz bands will revise their applications to comport with the envisioned multiple entry environment. With substantial adjustments to the proposed (continued...)

WARC-92 adopted a special coordination threshold in the form of an EIRP density level (-15 dBW/4 kHz in the part of the 1610-1626.5 MHz band used by aids to aeronautical navigation unless agreed to by the affected administrations). Applicants for mobile earth stations using may elect to operate at or below the -15 dBW/4 kHz level (e.g., using spread spectrum modulation). For instance, if we assume a transmission from a hand-held terminal with an EIRP of 2 dBW and a 7 kHz transmission rate, a spreading factor of 29 is required to reduce the EIRP density to the -15 dBW/4 kHz level. If a 200 chip per bit spreading ratio is selected, then individual mobile earth stations will be transmitting approximately at -23.4 dBW/4kHz. However, if a C/No of 42 dB/Hz is required at the receiving satellite, it appears that only about 87 other simultaneous transmissions can be tolerated within the spread bandwidth on a per beam basis assuming the system is interference limited. This estimate does not take into account any link margin needed to compensate for propagation effects like shadowing of the desired signal, and no self-interference is considered. In a recent study by Motorola, it was found that approximately 12 dB of margin is needed taking into account the effects of head blockage from a hand-held terminal served by non-geostationary satellites; protection of uplinks faded to this extent would further reduce uplink capacity. See Motorola submission to CCIR USSG 8D, Doc. USSG 8D-14, (October 28, 1992; new version being produced contemporaneously).

IV. DOWNLINK PFD LIMITS MUST BE ABSOLUTE FOR NON-GEOSTATIONARY SATELLITES, BUT SHOULD SERVE AS ONLY A COORDINATION TRIGGER FOR GEOSTATIONARY SATELLITES

The Commission proposes that the PFD generated on the Earth's surface by MSS satellites operating in the 2483.5-2500 MHz band be limited to the values specified in ITU Radio Regulation ("RR") 2566. NPRM, at ¶24. (The underlying motivation for the PFD limits is to protect the Fixed, Mobile, and Radiolocation services from interference caused by satellite emissions.) The Commission also notes, however, that MSS systems

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[10/] (...continued)
networks, higher capacity can be achieved than is shown in Table 3. See, for example, Technical Appendix, at 11-21, Consolidated Opposition to Petitions to Deny, AMSC, File Nos. 15-DSS-MP-91 and 16-DSS-MP-91, January 31, 1992. Even using a less restrictive PFD limit (RR 2562) and assuming certain modifications to the designs of the proposed CDMA systems, however, it was shown that each of the four proposed CDMA systems could provide only about 138 channels per beam at a poor quality of service or only 53 channels per beam at a better quality of service.

would be subject to coordination with respect to terrestrial services under RR Resolution 46 (formerly COM5/8) if the PFD values in RR2566 were exceeded. NPRM, at ¶24. As demonstrated below, the PFD values specified in RR2566 should be applied as a strict upper bound on PFD generated by non-geostationary MSS satellites, but only as a coordination trigger for geostationary MSS satellites. Even those non-geostationary networks operating at the PFD levels specified in RR2566 will severely interfere with terrestrial services, and so, coordination of a non-geostationary network exceeding the RR2566 PFD levels cannot be expected to be successful. In contrast, a geostationary domestic MSS satellite can exceed the PFD levels specified in RR2566 without causing unacceptable interference to terrestrial services.

In order to evaluate the interference caused to terrestrial services by non-geostationary MSS networks operating at the PFD levels of RR2566, it is necessary to simulate the operation of MSS networks to determine the statistics of the received interfering signal power for comparison with permissible levels for terrestrial services. This has been accomplished with respect to the Fixed service and representative non-geostationary MSS systems. Figures 1 and 2 show the cumulative time distributions of interference power received by a fixed station from MSS satellite constellations proposed by TRW (12 satellites at 10,239 km altitude) and Loral (48 satellites at 1,389 km altitude), respectively. These figures show that each of the MSS satellite constellations operating at the PFD levels specified in RR2566 would exceed single entry interference criteria that have been specified for the Fixed service by factors of up to 10 (in time).[11/] This is not at all surprising because as the transmitting non-geostationary satellites transit the sky, they frequently pass near or through the mainbeams of terrestrial receiving stations. The situation is even worse than portrayed by Figures 1 and 2, however, because each of several non-

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[11/] CCIR Report 382-6 and 448-5 provide single entry and aggregate interference criteria for the Fixed service in the form of interfering signal power levels that are not to be exceeded for more than specified percentages of the time. These criteria are based on performance objectives and interference allowances specified in other texts of CCIR Study Group 9. The permissible single entry levels of interfering signal power are -166.6 dBW/4 kHz and -129 dBW/4 kHz, which are to be exceeded for no more than 20% and 0.0017% of the time, respectively, assuming a digital receiver with 750 K noise temperature, a 4 kHz reference bandwidth corresponding with the PFD specifications of RR2566, and three interferers. The permissible aggregate levels of interfering signal power are -162 dBW/4 kHz and -129 dBW/4 kHz, which are to be exceeded for no more than 20% and 0.005% of the time, respectively.

geostationary MSS constellations seek to provide full-time coverage of any given location. Figure 3 shows the cumulative time distribution of interference caused by concurrent operation of just two of the non-geostationary satellite constellations (60 satellites) at the PFD levels specified by RR2566. Two non-geostationary networks operating at the RR2566 PFD levels exceed the aggregate long-term interference allowance two times longer (in time) than is permissible, which unacceptably reduces the availability of fixed systems. Consequently, the RR2566 PFD levels should not be exceeded by non-geostationary MSS systems, particularly in the multiple-operator environment that has been proposed by several of the non-geostationary MSS applicants.

In contrast, geostationary MSS satellites remain at the same location in the orbital arc and do not move through the mainbeams of receiving terrestrial stations. As a result, their interfering signal power is at a low level that depends on the angle between the receiving antenna mainbeam axis and the satellite. This is the specific frequency sharing situation that was used at WARC-79 as the basis for establishing the PFD levels specified in RR2566. Thus, the PFD levels of RR2566 can serve as a coordination trigger for geostationary MSS satellites under RR Resolution 46 just as they had previously under RR 2585. Moreover, the extent of coordination is limited in cases where the PFD specified in RR2566 is exceeded because domestic geostationary MSS systems confine their relatively high PFD levels to the United States and vicinity. For example, operation of downlinks at 30 dBW/4 kHz EIRP (i.e., among the highest EIRP levels that might be proposed by AMSC for any downlink in the 2483.5-2500 MHz band) through AMSC's proposed satellite antenna beams (62° W.L. satellite) in the 2483.5-2500 MHz band results in the RR2566 PFD levels being exceeded only in the cross-hatched area depicted in Figure 4, which include the U.S. and limited territory of Canada, Mexico, South America and Caribbean administrations as well as areas of the Atlantic and Pacific Oceans outside U.S. territorial waters.[12/] This assumes the satellite antenna discrimination levels indicated in AMSC's Application, dated June 3, 1991. The maximum discrimination contour indicated in the Application was -22 dB; even greater discrimination can be certified in the antenna design and development process. If so requested by these administrations, coordination of AMSC's downlinks would reveal that interference resulting from AMSC's PFD is at acceptable levels because of the high levels of antenna discrimination available from receivers located in the affected areas.

[12/] Systems in the Mobile and Radiolocation services may be operating in the 2483.5-2500 MHz band in Ocean areas. Administrations operating such systems may request coordination with respect to MSS operations exceeding the PFD levels of RR2566.

V. HAND-HELD UNITS POSE A SIGNIFICANT POTENTIAL RADIATION HAZARD

The Commission is concerned about the ability of hand-held devices to create RF fields that may be harmful to human health and requests comments on the likelihood that MSS non-geostationary hand-held terminals will not comply with RF exposure guidelines. NPRM, at ¶31-32. Although AMSC does not propose to serve hand-held mobile earth stations in its first generation geostationary system, such operations are anticipated for the second generation.[13] Significantly, in an earlier related filing, AMSC showed that its vehicular MSS earth stations would comply with RF exposure guidelines but that the hand-held terminals of at least one non-geostationary MSS Applicant would not be in compliance.[14]

AMSC recently performed a detailed near-field analysis to compare its earth stations' radiation characteristics with those of current terrestrial cellular terminals. Table 4 is a comparison of the relative power densities generated at various distances by the current generation of AMSC vehicular-mounted terminals, a 3 watt terrestrial cellular vehicular-mounted terminal using an 11 inch antenna and terrestrial cellular hand-held terminal using a 5 inch antenna. All these devices comply with the current RF exposure guidelines and, significantly, there have apparently been no adverse health problems attributed to terrestrial cellular terminals. The results show that the power density of an AMSC terminal is less that of a vehicular cellular terminal in the near field, mainly because the size of the MSS antenna is larger (30 in. as compared to 11 in.). At a distance of 10 inches, the effects of the directivity of the AMSC mast antenna comes into play since the MSS antenna was designed with directivity in the elevation direction to improve performance.

It makes intuitive sense that the hand-held terminal would have the lowest power density profile despite the fact that it operates with a smaller antenna. Most of the non-geostationary MSS hand-held devices require antenna input power greater than 600 miliwatts; it appears likely that the power density of these MSS hand-helds would be somewhere in between the levels of the terrestrial vehicular and hand-held units. It should also be

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[13] See Petition of AMSC. June 3, 1991, Exhibit B. AMSC's contemplated hand-held terminals fully comply with RF exposure guidelines.

[14] See Consolidated Opposition to Petitions to Deny, AMSC, File Nos. 15-DSS-MP-91 and 16-DSS-MP-91, January 31, 1992, Technical Appendix, at 25-26.

noted that the largest power densities appear at the base of the hand-held antenna, which is closest to the head of the user, and that the radiation standard for power density is f/300 mw/cm^2, where f is the frequency in MHz. As an example for a non-geostationary MSS hand-held terminal, if we consider a 2-watt antenna input power at 1613 MHz and scaling of the field strength measurement from the table above, the strength of the power density would be around 15 mw/cm^2 in comparison with the standard of 5.38 mw/cm^2. Consequently, AMSC believes that there is a potential radiation hazard associated with non-geostationary MSS hand-held terminals that require in excess of 600 milliwatts of antenna input power.

VI. GEOSTATIONARY AND NONGEOSTATIONARY SATELLITE SYSTEMS USING ANY COMBINATION OF MULTIPLE ACCESS TECHNIQUES CAN SHARE THE 1610-1626.5/2483.5-2500 MHz BANDS

The Commission states that sharing between non-geostationary and geostationary systems may not be feasible because the power and frequency limits that may be needed to prevent interference might render both types of systems unworkable. NPRM, ¶17. The Commission requests comments on this matter and on the impact multiple access techniques may have on the MSS allocation and the ability to share spectrum among multiple MSS systems. NPRM, ¶19. The choice among, or intermingling of non-geostationary and geostationary satellites or multiple access techniques has no direct bearing on the ability to share the 1610-1626.5/2483.5-2500 MHz bands among multiple networks or the MSS allocations therein. Specifically, non-geostationary and geostationary MSS networks can adhere to the same multiple entry standards in order to preclude mutual interference (even in cases where different power levels are used) and any or all of the proposed multiple access techniques can be applied in the multiple entry environment.

A. Non-geostationary and Geostationary Satellites Already Share The Same Frequency Bands and Can Do So In This Case

There are several bands now shared by non-geostationary and geostationary satellites in a manner analogous to the situation at hand. For example, the 1690-1700 MHz band is shared by geostationary and non-geostationary satellite downlinks in the Meteorological-Satellite Service (e.g., GOES and NOAA-9). More to the point, the 1544-1545 MHz "distress and safety" band is shared by geostationary satellites (Inmarsat II) and non-geostationary satellites (COSPAS/SARSAT), which are MSS systems providing safety services. Moreover, several of the non-geostationary MSS applicants included analyses indicating that their networks could share with geostationary satellites in the RDSS. There simply is no basis in actual practice for claiming that non-geostationary networks cannot share frequency bands with geostationary networks.

Sharing between a variety of geostationary and non-geostationary systems in the subject bands is no more difficult than sharing between different geostationary satellite systems or different non-geostationary satellite systems. All the MSS applicants as well as Inmarsat are proposing service to low-powered mobile satellite terminals that have antennas with little angular discrimination in either azimuth or elevation. Terminals will receive transmissions from all MSS satellites (whether non-geostationary or geostationary) that are operating on the same frequency and serving the same area. Similarly, transmissions from the terminals will emanate in all directions so that any non-geostationary or geostationary satellite that is serving the area will receive the terminal's transmission. Since the direction of transmission is not a factor with these types of mobile terminals when calculating the potential interference, the intersystem interference environment does not substantially change in considering a geostationary or a non-geostationary satellite or any combination of the two types of systems.

What appears to have obfuscated an understanding of the potential for sharing between non-geostationary and geostationary satellites is the mistaken belief that there is a fundamental difference in the terminal uplink EIRP requirements for non-geostationary and geostationary systems. No such difference exists. The basic transmission loss to a geostationary satellite will always be greater than that to a non-geostationary satellite. This is a function of the distance of the earth station to the satellite. However, interference among networks is proportional to EIRP density, and an earth station's EIRP requirement for operation with a satellite system whose satellite antenna beams are covering identical service areas is independent of the orbit. For instance, if a geostationary satellite generates the same antenna beam footprint as a non-geostationary system, then an earth station's EIRP density requirement is the same for either system. In this example, the geostationary satellite system offsets the greater propagation loss with high satellite antenna gain (i.e., in providing the same beam coverage, the antenna beamwidth decreases when the altitude of the orbit increases). Even if the geostationary satellite antenna has a larger beam coverage area than a non-geostationary satellite, the associated uplink EIRP densities could be the same by virtue of greater signal spreading in the geostationary network. Moreover, because the total EIRP density reaching the satellite is of concern, the geostationary network could simply operate fewer channels at higher EIRP density than the non-geostationary network. For downlinks, mobile earth stations require the same PFD regardless of satellite orbit. [15/]

B. Any or All of the Proposed Multiple Access Techniques Can Be Applied in the Multiple Entry Environment

All of the proposed non-geostationary and geostationary MSS systems use Frequency Division Multiple Access ("FDMA") as a means for splitting the spectrum into channels in order to gain discrimination sufficient to support independent MSS operations (i.e., freedom from interference) in the same frequency band. Consequently, FDMA could be used as a basis for multiple entry. In effect, the band is divided into segments with each network using its own segment. This also applies to FDMA systems using a Time Division Multiple Access sub-layer ("FDMA/TDMA") such as has been proposed by Motorola. As discussed above, the FDMA approach can be used to achieve multiple entry among several networks.

An MSS system using FDMA with a Code Division Multiple Access sub-layer ("FDMA/CDMA") can operate co-channel with other systems using any access technique provided that power densities are properly balanced in order to preclude unacceptable interference. For example, assume that each of the bits transmitted in a CDMA system are spread by 200 chips. If it is assumed that the required C/No is 42 and that the terminal G/T is

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[15/] To further illustrate by way of example, assume that all systems are using vocoded voice on narrowband channels at a rate of 4.8 Kbps, operating on a communication channel with a nominal transmission rate of 7 Kbps, which takes into account coding and system overhead. If we assume that the required Eb/No is 8.5 dB, then the received C/No at the earth station must be 46.9 dB. To produce a C/No of this amount in a receiver with a G/T of -22 dB/K, the satellite must generate a threshold PFD of about -136 dBW/m2/4 kHz at the terminal, whether it is a non-geostationary or geostationary satellite. Thus, if two non-geostationary systems, two geostationary systems, or a non-geostationary and a geostationary system are generating the same PFD at the same carrier frequency in the same area, the C/I is 0 dB and the C/No+Io is below threshold, and so, communications to the terminal become impossible. In this example, the only solution is for the two systems to operate in separate segments of the band. The analysis for the Earth-to-space direction of transmission would be similar and the conclusion would be the same. Likewise, if the systems were using the entire band with spread spectrum modulation, then each system would relinquish capacity in order to accommodate other systems.

-22 dB/K, then the individual signal power level needed to overcome the effects of noise is -161.6 dBW. By increasing the signal power by 3.5 dB, approximately 80 simultaneously overlapping transmissions can be made in the same system using the same (spread) bandwidth (assuming use of orthogonal codes) or about 50 simultaneously overlapping transmissions can be made by other systems using the same bandwidth.

It is also possible to intermingle FDMA, FDMA/TDMA, and FDMA/CDMA multiple access techniques, which are the only techniques proposed by the applicants. For example, uplink EIRP density and downlink PFD levels could be adjusted so as to produce acceptable levels of co-channel interference in each type of system. As an alternative to adjusting network parameters to allow FDMA and FDMA/TDMA systems to share with FDMA/CDMA systems on a co-channel basis, band segmentation could be used to allow FDMA/CDMA operation in one part of the band and other access techniques in the other part of the band.

Table 1 Glonass Protection Areas

Uplink Power Density (dBW/4 kHz)	Required Separation Distance (dB(km))	Required Separation Distance (km)	Blackout Area for an Aircraft at 25000 ft (square miles)	Blackout Area for an Aircraft at 45000 ft (square miles)
-5	57.5	749.9	682019.3	681861.6
-10	52.5	421.7	215625.3	215467.5
-15	47.5	237.1	68138.6	67980.8
-20	42.5	133.4	21499.1	21341.4
-25	37.5	75.0	6750.5	6592.7
-30	32.5	42.2	2086.5	1928.8
-35	27.5	23.7	611.7	453.9
-40	22.5	13.3	145.3	N/A

Table 2 Comparison of power flux density ("PFD") produced at receiving stations by MSS downlinks and MSS uplinks

VICTIM RECEIVING STATION IN PRIMARY SERVICE	PFD PRODUCED BY SECONDARY MSS DOWNLINK (Note 1)	PFD PRODUCED BY PRIMARY MSS UPLINK
Glonass Aircraft Earth Station Receiver (Note 2)	-120 dBW/m^2/4 kHz	-120 dBW/m^2/4 kHz
Fixed Radio-Relay Receiver (Note 3)	-120 dBW/m^2/4 kHz	-120 dBW/m^2/4 kHz
MSS Satellite Receiver (Note 4)	-123 dBW/m^2/4 kHz	-144 dBW/m^2/4 kHz

Note 1. The interfering signal power flux density specified for MSS downlinks is based on the parameters proposed by Motorola in its Minor Amendment dated August 8, 1992. Motorola specifies a time-averaged PFD of -135.8 dBW/m^2/4 kHz for all angles of arrival, but the peak-to-average time and bandwidth adjustment factors yield a peak PFD of -120 dBW/m^2/4 kHz for all angles of arrival on Earth. Peak rather than time-averaged PFD levels are of importance with respect to victim systems using digital modulation. The PFD generated by the MSS downlinks at a receiving MSS satellite is 3 dB less than the values impinging on Earth assuming that the transmitting and receiving satellites have the same orbital altitude and are located in a plane tangent to the Earth (i.e., maximum separation while visible). In cases where the receiving satellite is closer to the transmitting satellite, substantially higher interfering PFD may be generated by the transmitting satellite.

Note 2. For the MSS uplink, it is assumed that the mobile earth station has -15 dBW/4 kHz EIRP and is located 50 km from the victim receiver. No aircraft shielding has been applied to reduce mobile earth station PFD impinging on the Glonass antenna. Although AMSC's proposed narrowband uplinks would have EIRP higher than -15 dBW/4 kHz, AMSC also proposes to operate uplinks only above 1616.5 MHz which provides substantial guardband with respect to Glonass signals for public access. In contrast, Motorola proposes MSS downlink signals as low as about 1616.0315 MHz (Minor Amendment, Figure R-7), which provides virtually no guardband with respect to the Glonass channel spanning 1614.989 MHz - 1616.011 MHz.

Note 3. For the MSS uplink, it is assumed that the mobile earth station has -15 dBW/4 kHz EIRP and is located 50 km from the victim receiver. Although AMSC's proposed narrowband uplinks would have EIRP higher than -15 dBW/4 kHz, AMSC proposes to serve only the U.S. and the closest fixed station operating under RRs 727 and 730 is located over 1000 km from the U.S.

Note 4. For the MSS uplink, it is assumed that the mobile earth station has -15 dBW/4 kHz EIRP and is located 780 km from the victim satellite. Although AMSC's proposed narrowband uplinks would have EIRP higher than -15 dBW/4 kHz, AMSC reserved the right to utilize spread spectrum modulation or other techniques that will comport with the multiple access rules that are to be developed. AMSC Application, June 3, 1991, Exhibit A, at 7.

Table 3 System Capacity Estimates Using the New PFD Limits

Satellite	Maximum Power (dBW)	Threshold C/No (dB/K)	Required Signal Power (dBW)	Maximum Number of Channels
Constellation	19.5 per TDM carrier	53.4 per TDM carrier	-140.1	2 TDM carriers
Ellipsat	22 per 1.4 MHz channel	40.8	-152.7	2 per 1.4 MHz channel
Loral	13.8 dBW per beam	40.3	-153.2	5 per beam
TRW	24.3 per beam	43.7	-149.8	0

Table 4 - Comparison of Terminal Power Densities

Distance (inches)	AMSC 5 Watt Mast (mw/cm^2)	3 Watt Terrestrial Cellular (mw/cm^2)	0.6 Watt Portable (mw/cm^2)
1.0	16.8	194.8	4.7
5.0	1.03	1.6	0.34
10.0	0.56	0.46	0.13

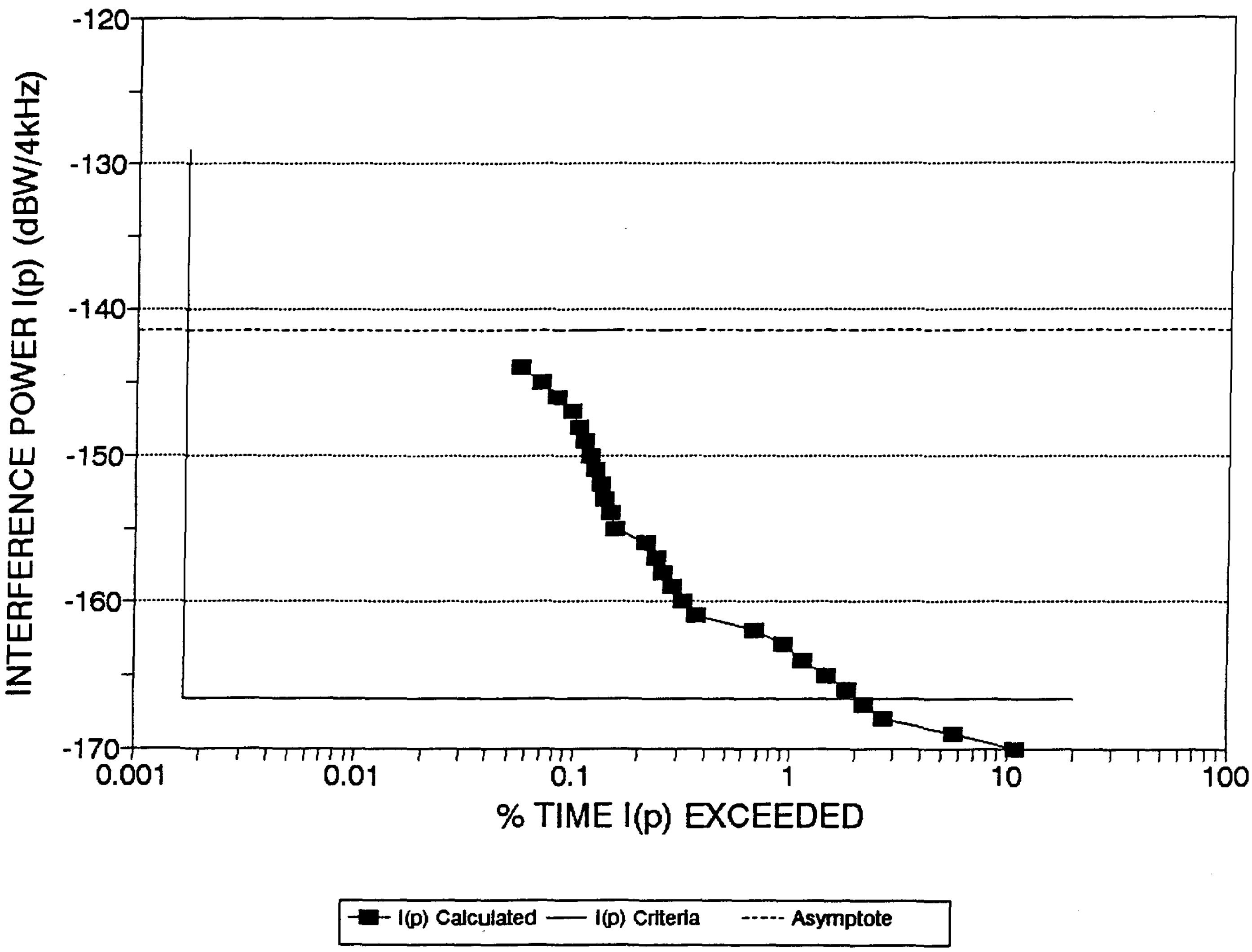

Figure 1. Comparison of Permissible Interference With Interference Caused By Operation of TRW MSS Satellites at the PFD Limit of RR 2566

Notes:

1. The victim fixed station is located at 25° North latitude with a mainbeam azimuth of 129° and antenna gain of 40 dBi.

2. The computer simulation addressed one day of operation and performed interference calculations at intervals of 0.1 minute.